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Indian Standard

SPECIFICATION FOR HEAT RESISTING STEELS

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Indian Standard

SPECIFICATION FOR HEAT RESISTING STEELS

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(*Continued on page* 20)

Indian Standard

SPECIFICATION FOR HEAT RESISTING STEELS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 29 April 1980, after the draft finalized by the Alloy Steels and Special Steels Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 In order to effect variety reduction and to promote economic production of alloy and special steels in the country, IS : 1570-1961* was published as a part of the steel economy programme of the Indian Standards Institution. It has served as the basic standard for specifying steel compositions in all the Indian Standards relating to material specifications. IS : 1570-1961* has now been published in parts as follows:

Part I	Steels specified by tensile and/or yield properties
Part II	Carbon steels (unalloyed steels)
Part III	Carbon and carbon manganese free cutting steels
Part IV	Alloy steels (other than stainless and heat resisting steels) with specified chemical composition and related mechanical properties†
Part V	Stainless and heat-resisting steels
Part VI	Tool steels†

0.2.1 In view of the fact that a number of requirements, such as limits for sulphur and phosphorus, method of deoxidation, and additional tests for specific purposes, have been left to be specified in individual specifications; need was felt that detailed Indian standards be prepared on the basis of which material could be indented for. Accordingly this detailed specification has been prepared.

0.3 While formulating this standard, due consideration has been given to Draft International Standard ISO/DIS 4955 ' Heat resisting steels and alloys ' issued by International Organization for Standardization (ISO).

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*Schedules for wrought steels for general engineering purposes.

†Under preparation.

0.4 The steel designations given in this standard are in line with IS : 1762 (Part I)-1974*.

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960†. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard specifies the requirements for three grades of wrought heat-resisting steels. These steels are usually employed for products, for which the resistance to the effects of hot gases and products of combustion at temperatures in the region above 550°C, is the main requirement.

1.2 This standard does not cover the requirements for creep resisting steels and for valve steels for internal combustion engines (*see* IS : 7494-1974‡).

1.3 Unless otherwise stated, this Indian Standard applies to all types of hot-worked or cold-worked products which are supplied in the heat-treated condition. However, not all the steels included in this standard are necessarily available in all product forms.

2. SUPPLY OF MATERIAL

2.1 General requirements relating to supply of material shall conform to IS : 1387-1967§.

2.2 Steels covered by this standard shall be delivered in accordance with one of the requirement classes given in Table 1.

2.3 Surface and heat treatment condition of delivery shall be agreed at the time of enquiry and order.

2.3.1 The properties given in Table 2 shall be applicable to thicknesses (sizes) and usual heat treatment conditions, specified in Table 2. For thicknesses and heat treatment conditions not covered in Table 2, the delivery shall be on the basis of chemical composition only.

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*Code for designation of steels: Part I Based on letter symbols (*first revision*).

†Rules for rounding off numerical values (*revised*).

‡Steel for valves for internal combustion engines.

§ General requirements for the supply of metallurgical materials (*first revision*).

TABLE 1 REQUIREMENT CLASSES

(*Clause* 2.2)

Sl No.	Requirement	Requirement Classes		
		1	2	3
(1)	(2)	(3)	(4)	(5)
1.	Chemical composition	×	×	×
2.	Hardness in the usual heat treatment condition	—	×	—
3.	Tensile properties in the usual heat-treatment conditions	—	—	×

3. MANUFACTURE

3.1 Unless otherwise agreed in the order, the steel making process used shall be at the discretion of the manufacturer. When he so requests, the purchaser shall be informed what process is being used.

4. FREEDOM FROM DEFECTS

4.1 The material shall be free from harmful internal and surface defects.

5. CHEMICAL COMPOSITION

5.1 The ladle analysis of steels, when tested in accordance with relevant parts of IS : 228* shall be as given in Table 4.

5.2 Product Analysis — Product analysis shall be carried out on the finished product. Permissible variation in the case of product analysis on the limits specified in Table 4 shall be as given in Table 5.

5.3 Elements not specified in Table 4 shall not be added to the steel, except where agreed to, other than for the purpose of finishing the heat, and shall not exceed the following limits:

Constituent	*Percent*
Molybdenum	0·50
Copper	0·35
Vanadium	0·05
Nickel	0·50

---

*Methods of chemical analysis of steel (*second revision*) (being issued in parts).

TABLE 2 HARDNESS AND TENSILE PROPERTIES FOR THE STEELS IN THE USUAL HEAT-TREATMENT CONDITION

(*Clauses* 2.3.1, 6.1 *and* 6.2)

STEEL DESIGNATION	PRODUCT	THICKNESS	HEAT* TREATMENT	MECHANICAL PROPERTIES			
				Hardness *Max*	0·2 Percent Proof Stress *Min*	Tensile Strength *Min*	Elongation Percent on Gauge Length $5.65\sqrt{S_0}$† *Min*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		mm		HB	‡MPa	MPa	
X 15 Cr 25 N	Plates, sheets	≥ 0·5 ≤ 5	Annealed	212	280	490	16
	Strip	≥ 0·5 ≤ 5					
	Tubes	≥ 0·5 ≤ 5					
	Bars	≥ 5 ≤ 15					
	Forgings	≥ 5 ≤ 15					
	Wire	≥ 1·5 ≤ 15					
X 15 Cr 24Ni13	Plates, sheets	≥ 0·5 ≤ 30	Quenched	223	210	490	40
	Strip	≥ 0·5 ≤ 5					
	Tubes	≥ 0·5 ≤ 20					
	Bars	≤ 100					
	Forgings	≤ 100					
	Wire	≥ 1·5 ≤ 15					
X 20 Cr 25Ni20	Plates, sheets	≥ 0·5 ≤ 30	Quenched	223	210	490	40
	Strip	≥ 0·5 ≤ 5					
	Tubes	≥ 0·5 ≤ 20					
	Bars	≤ 100					
	Forgings	≤ 100					
	Wire	≥ 1·5 ≤ 15					

**See also* Table 3.

†S_0 = Cross-sectional area (mm²).

‡1 MPa ≠ 1 N/mm² = 0·102 0 kgf/mm².

TABLE 3 HEAT TREATMENT (Data for Guidance only)

(*Table* 2)

STEEL DESIGNATION	HEAT TREATMENT		
	Symbol*	Temperature °C	Quenching Media†
(1)	(2)	(3)	(4)
×15 Cr25N	A	825	a, w
×15 Cr24Ni13	Q	1 100	w, a
×20 Cr25Ni20	Q	1 100	w, a

*A = annealed, and Q = quenched.
†a = air, and w = water.

NOTE 1 — Whether the quenching has to be done in air or water will depend on the thickness of the material.

NOTE 2 — Depending on the degree of cold-work applied to the product and the type of furnace employed in heat treatment, the quenching temperature can vary to a considerable degree to enable the properties to be achieved.

6. MECHANICAL PROPERTIES

6.1 When ordered according to requirement class 2 and to heat treatment condition given in Table 2, the maximum Brinell hardness values specified in Table 2 shall apply.

6.2 When ordered according to the requirement class 3 and to the heat treatment condition given in Table 2, the tensile properties specified in Table 2 shall apply.

6.3 There are some additional material properties for which, however, it is impossible at present to lay down clear requirements. As far as appropriate and possible, Appendix A gives technical information about these properties.

7. DIMENSIONS AND TOLERANCES

7.1 The dimensions and tolerances shall be as agreed at the time of enquiry and order.

TABLE 4 CHEMICAL COMPOSITION

(*Clauses* 5.1 *to* 5·3 and *Table* 5)

Steel Designation [*See* IS : 1762 (Part I) - 1974*]	Carbon *Max*	Silicon *Max*	Manganese *Max*	Nickel	Chromium	Nitrogen	S *Max*	P *Max*	Remarks
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
× 15 Cr25 N	0·20	1·0	1·5	—	23·0 to 27·0	0·10 to 0·25	0·030	0·045	Ferrite
× 15 CR24 Ni13	0·20	1·5	2·0	11·0 to 15·0	22·0 to 25·0	—	0·030	0·045	Austenitic
× 20 CR25 Ni20	0·25	2·5	2·0	18·0 to 21·0	24·0 to 26·0	—	0·030	0·045	Austenitic

*Code for designation of steel: Part I Based on letter symbols (*first revision*).

TABLE 5 PERMISSIBLE VARIATION OVER THE LIMITS SPECIFIED IN TABLE 4

(*Clause* 5.2)

Constituent (1)	Percent (2)	Permissible Variation, Percent (3)
Carbon	Up to and including 0·25	+0·02
Silicon	Up to and including 1·0	+0·05
	Over 1·0 up to and including 2·0	+0·07
	Over 2·0	+0·10
Manganese	—	+0·04
Nickel	11·0 to 15·0	±0·15
	18·0 to 21·0	±0·20
Chromium	22·0 to 27·0	±0·25
Sulphur	—	+0·005
Phosphorous	—	+0·005
Nitrogen	—	+0·02

8. TESTING

8.1 Number of Sample Products

8.1.1 *Chemical Composition* — If requested at the time of enquiry and order, the ladle analysis shall be reported by the manufacturer. If a product analysis is required by the purchaser and unless otherwise agreed at the time of enquiry and order, one sample product shall be taken from each cast.

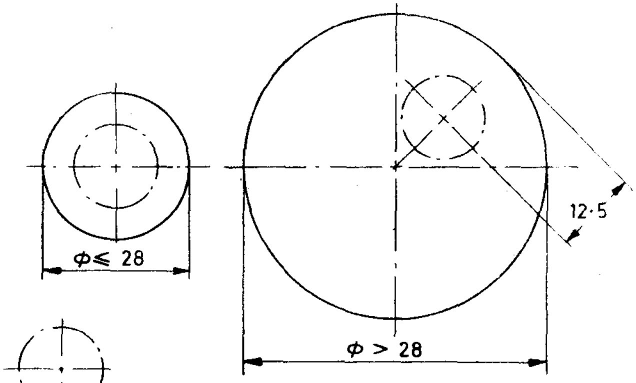
8.1.2 *Mechanical Properties* — One sample product shall be tested for each cast and for each separate heat-treatment batch. All material from the same continuous heat treatment operation, during the same operating period, is considered to be of the same heat-treatment batch.

8.2 Samples and Test Pieces

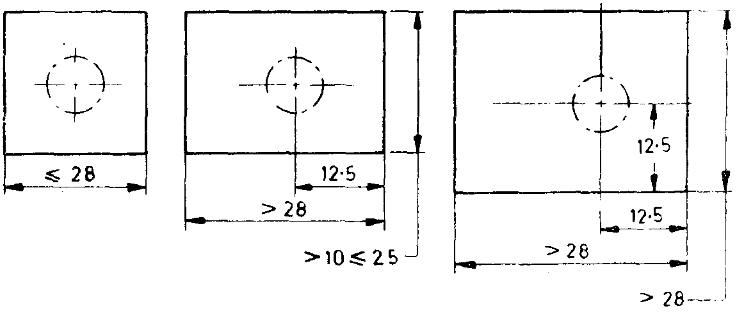
8.2.1 One sample per cast shall be taken for the purpose of product analysis, hardness test and tensile test.

8.2.2 For the tensile test, one longitudinal test piece is to be taken:

For bars: according to Fig. 1 and IS : 3711-1966*
For wire: according to Fig. 1 and IS : 3711-1966*
For tubes: according to Fig. 2 and IS : 3711-1966*
For flat products: in case of dispute, according to Fig. 1 and IS : 3711-1966* otherwise the manufacturer is permitted to use transverse test pieces taken in accordance with Fig. 3.



CIRCULAR SECTION



RECTANGULAR SECTIONS

All dimensions in millimetres.

FIG. 1 LOCATION OF THE TENSILE TEST PIECES IN BARS AND WIRE

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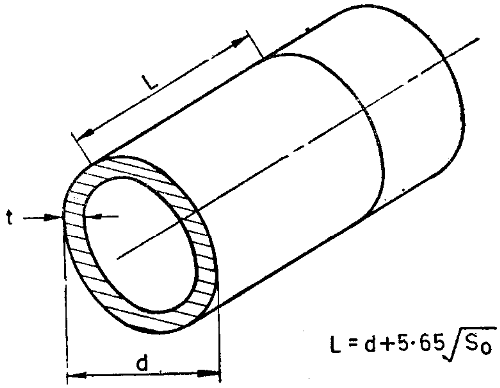
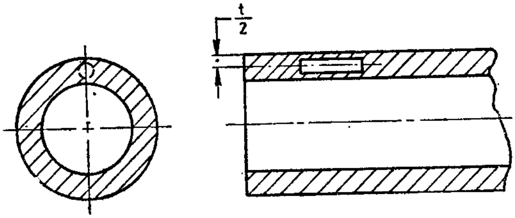
*Method for selection and preparation of samples and test pieces for mechanical tests for wrought steel.



(a) SAMPLE

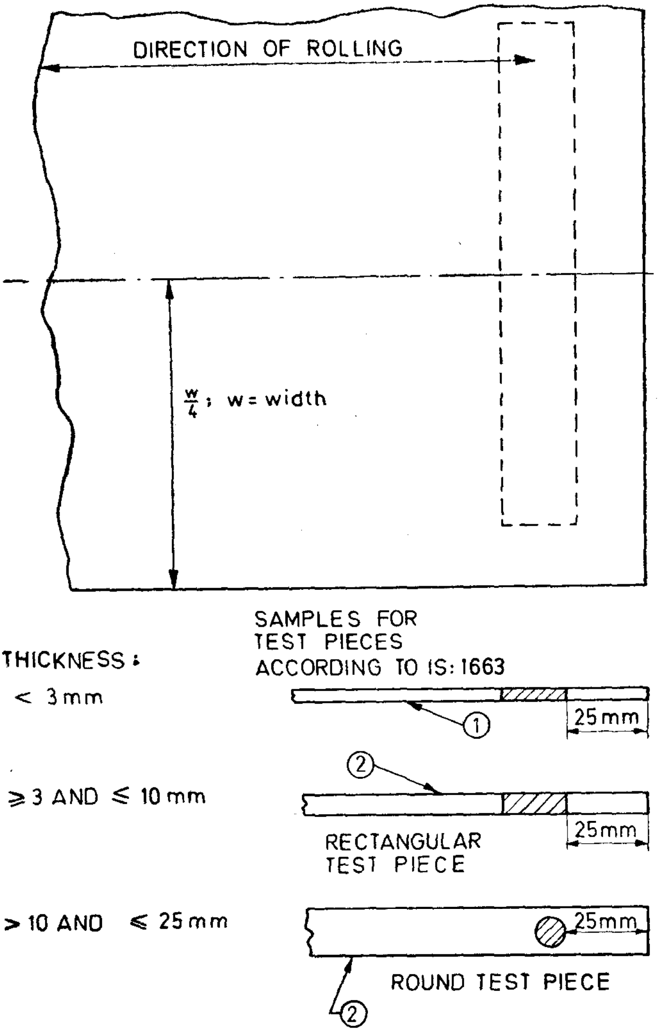


(b) TEST PIECE

NOTE 1 — The test piece shall be either a full section test piece according to IS : 1894 - 1972 ' Method for tensile testing of steel tubes (*first revision*) ', identical to the sample at (a) above; or

NOTE 2 — A round longitudinal tensile test piece according to IS : 1608 - 1972 ' Method for tensile testing of steel products (*first revision*)', as shown at (b) above.

FIG. 2 LOCATION AND TYPE OF THE TENSILE TEST PIECE FOR TUBES



NOTE 1 — IS : 1663 - 1972 'Method for tensile testing of steel sheet and strip of thickness 0·5 mm' recommends test pieces either of 20 mm width and 80 mm gauge length or of 12, 5 mm width and 50 mm gauge length, the latter being only for thickness ⩾0, 5 and ⩽2 mm. (The elongation values for test pieces must be agreed).

NOTE 2 — Gauge length in cases of dispute: $L_0 = 5{\cdot}65\sqrt{S_0}$ (S_0 = cross-sectional area of the test piece).

FIG. 3 LOCATION OF THE TENSILE TEST PIECES IN SHEET, STRIP OR PLATE

9. RE-TESTS

9.1 Re-test for Product Analysis — If the results of the product analysis do not meet the composition requirements given in Tables 4 and 5, two new samples shall be taken on different pieces from the same cast, unless otherwise agreed to between the purchaser and the manufacturer. Should the two analysis satisfy the requirements, the lot represented shall be accepted. If either of the tests fail, the material shall be taken as not complying with this standard.

9.2 Re-test for Hardness and Mechanical Tests in the Heat-Treated Condition — If the sample selected under **8.1** and **8.2** fail to meet the requirements under **6**, two further samples shall be selected from the same heat treatment batch or lot. The consignment shall be considered as conforming to the requirements if both the additional tests are satisfactory. If either of the samples fail, the manufacturer shall have the option to heat-treat the product in any suitable manner before two fresh samples are taken for testing. If the two tests satisfy the requirements of this standard, the lot represented shall be accepted. If either of the samples fail, the material shall be taken as not complying with this standard.

10. PACKING AND MARKING

10.1 Steel shall be suitably packed or bundled. A metal tag giving the following information, shall be attached to each packet or bundle:

a) Name and trade-mark of the manufacturer;

b) Steel grade; and

c) The cast number or any other identification mark by which the steel can be traced to the cast and heat treatment batch from which it was made.

10.1.1 The colour scheme specified in IS : 2049-1963*, or as required by the purchaser, may be adopted to mark the grade of the material.

10.2 The material may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act and the Rules and Regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

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*Colour code for the identification of wrought steels for general engineering purposes.

APPENDIX A

(*Clause* 6.3)

TECHNICAL INFORMATION ON HEAT RESISTING STEELS

A-1. INTRODUCTION

A-1.1 This Indian Standard covers those requirements which can be clearly defined and which seem necessary to specify a material of fairly uniform properties. In the following, these requirements are supplemented by indications on some further important properties which for one reason or another, for example, because of difficulties in their verification or because they are based on too limited a number of tests, cannot, at present, be formulated as requirements but should be regarded as technical information.

A-2. HEAT RESISTANCE

A-2.1 The steels and alloys given in Table 4 have, by virtue of their alloy content, an increased resistance to attack by hot gases and combustion products. This resistance, and consequently the maximum service temperature of the materials, is however largely dependent on the conditions of attack. For use in clean air or hydrogen, under conditions where the mechanical stresses (*see* Table 6) are unimportant with regard to service life, the maximum service temperature indicated in Table 6 can be taken as a guide.

A-2.2 A warning is given that when the material is to be used in atmospheres other than clean air or hydrogen, then the values in Table 6 should not be taken as applicable for the maximum temperature of use. In such cases the rate of oxidation of the steels can be significantly increased, depending on their chemical composition and as a consequence, the maximum temperature of use can be reduced considerably and could be, for example, several hundred degrees lower than the temperatures in Table 6.

A-3. CREEP RESISTANCE

A-3.1 In Table 7, the average creep stresses for 1 percent elongation and ruptureafter durations of 1 000 and 10 000 hours are given for guidance only (*see* Note 1 of Table 7).

A-4. PHYSICAL PROPERTIES

A-4.1 In Table 8 the physical properties of the steels are given for guidance.

TABLE 6 MAXIMUM APPLICATION TEMPERATURE T_a FOR AIR FOR HYDROGEN (For Guidance only)

(*Clause* A-2.1)

Steel Designation	T_a Max, °C
×15 Cr 25N	1 000
×15 Cr 24Ni13	1 000
×20 Cr 25Ni20	1 150

A-5. TECHNOLOGICAL PROPERTIES

A-5.1 The steels are suitable for hot working. The optimum hot-working conditions shall, where necessary, be requested from the manufacturers.

A-5.2 The steels are suitable for cold-forming. It is, however, recommended that ferritic steels be annealed before working. Futhermore, the worked tendency of austenitic steels to work-harden should be noted.

A-5.3 The steels may generally be welded by the usual welding processes. It is, however recommended that users who have not had experience in welding these materials should consult the suppliers regarding appropriate welding conditions. Additionally, the tendency of ferritic steels to grain growth when being welded should be taken into account.

A-5.4 ×15Cr25N grade steel is embrittled if held in the range of 400-540°C. The embrittlement is maximum at 475°C, resulting in increased hardness and less toughness and ductility. This steel is also susceptible to extreme loss in ductility and toughness when cooled from temperature above 1 000°C. This steel is also susceptible to notch sensitivity.

A-5.5 Compared to austenitic stainless steels, grade ×15Cr25N (ferritic) stainless steel is preferably used in atmospheres containing sulphur.

A-5.6 Among the austenitic stainless steels, the higher nickel austenitic stainless steel is preferred where intermittent heating and cooling are encountered as they form more adherent scale. These steels are preferable to ferritic stainless steels in all applications excepting where sulphurous atmospheres are involved.

TABLE 7 CREEP RUPTURE PROPERTIES (For Guidance only)

(*Clause* A-3.1)

Steel Designation	Heat Treatment	Duration of Stress, Hours	Estimated Average Creep Stress, N/mm^2 at Temperature T°C											
			For One Percent Elongation						Rupture					
			500	600	700	800	900	1 000	500	600	700	800	900	1 000
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
× 15Cr 25N	A	1 000	80	27·5	8·5	3·7	1·8	—	160	55	17	7·5	3·6	—
		10 000	50	17·5	4·7	2·1	1·0	—	100	35	9·5	4·3	1·9	—
× 15Cr 24Ni13	Q	1 000	—	120	50	20	8	—	—	190	75	35	15	—
		10 000	—	80	25	10	4	—	—	120	36	18	8·5	—
× 20Cr 25Ni20	Q	1 000	—	105	50	23	10	5	—	170	60	40	20	—
		10 000	—	95	35	10	4	—	—	130	60	20	10	—

Note 1 — The values given are in many cases based on sparse data, consequently they shall be regarded as preliminary. Furthermore, test data are requested from all appropriate sources for use in the completion and where necessary, correction of the tabular values.

Note 2 — A = annealed, and Q = quenched.

TABLE 8 PHYSICAL PROPERTIES FOR THE STEELS (For Guidance only)

(*Clause* A-4.1)

STEEL DESIGNATION	DENSITY g/cm^3	COEFFICIENT OF THERMAL EXPANSION, 10^{-6}/°C, BETWEEN 20°C AND					HEAT CONDUCTIVITY, *w/m*°C		SPECIFIC HEAT CAPACITY, J/g°C at 20°C	ELECTRICAL RESISTIVITY, Ωmm^2/m, at 20°C	MAGNETISABILITY
		200°C	400°C	600°C	800°C	1 000°C	at 20°C	at 500°C			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
× 15 Cr 25N	7·7	10·5	11·5	12·0	12·5	13·5	17	23	0·50	1·1	Yes
× 15 Cr 24Ni13	7·9	16·5	17·5	18·0	18·5	19·5	15	21	0·50	0·85	No*
× 20 Cr 25Ni20	7·9	15·5	17·0	17·5	18·0	19·0	15	19	0·50	0·90	No*

*Slightly magnetic when cold-worked.

INDIAN STANDARDS ON ALLOY STEELS AND SPECIAL STEELS

Title of Indian Standard

IS : 963-1958 Chrome molybdenum steel bars and rods for aircraft purposes

IS : 1570-1961 Schedules for wrought steels for general engineering purposes

IS : 1570 (Part V)-1972 Stainless and heat resisting steels

IS : 1870-1965 Comparison of Indian and overseas standards for wrought steels for general engineering purposes

IS : 1871-1965 Commentary on Indian standards schedules for wrought steels for general engineering purposes

IS : 3739-1972 Dimensional tolerances for carbon and alloy constructional steels products

IS : 3748-1978 Tool and die steels for hot work (*first revision*)

IS : 3749-1978 Tool and die steels for cold work (*first revision*)

IS : 3930-1978 Flame and induction hardening steels (*first revision*)

IS : 4368-1967 Alloy steel billets, blooms and slabs for forging for general engineering purposes

IS : 4397-1973 Cold rolled carbon steel strips for ball and roller bearing cages (*first revision*)

IS : 4398-1973 Carbon chromium steel for the manufacture of balls, rollers and bearing races (*first revision*)

IS : 4430-1978 Mould steels (*first revision*)

IS : 4431-1978 Carbon and carbon manganese free cutting steels (*first revision*)

IS : 4432-1968 Steel for case hardening purposes

IS : 4882-1979 Low carbon steel wire for rivets for use in bearing industry

IS : 5489-1975 Carburizing steels for use in bearing industry (*first revision*)

IS : 5517-1978 Steels for hardening and tempering (*first revision*)

IS : 5518-1978 Steels for die blocks for drop forging (*first revision*)

IS : 5522-1978 Stainless steel sheets and coils

IS : 5651-1970	Steels for pneumatic tools
IS : 6527-1972	Stainless steel wire rod
IS : 6528-1972	Stainless steel wire
IS : 6529-1972	Stainless steel blooms billets, and slabs and forgings
IS : 6603-1972	Stainless steel bars and flats
IS : 6911-1972	Stainless steel plate, sheet and strip
IS : 7291-1974	High speed tool steel
IS : 7494-1974	Steel for valves for internal combustion engines

(*Continued from page* 2)

Members	*Representing*
Shri B. C. Basavaraj	Visvesvaraya Iron & Steel Ltd, Bhadravati
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Shri Chattaraj	Fertilizer Corporation of India, Sindri
Shri P. R. Roy (*Alternate*)	
Shri S. V. Datar	Ahmedabad Advance Mills Ltd, Navsari
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Dr R. V. Pathy	Mahindra Ugine Steel Co Ltd, Bombay
Shri R. Narayanan (*Alternate*)	
Scientist-in-Charge	National Metallurgical Laboratory (CSIR), Jamshedpur
Shri D. D. Sharma	Chemical Plant & Machinery Association of India, Bombay
Shri Y. L. Midha (*Alternate*)	

AMENDMENT NO. 1 MARCH 1983

TO

IS:9516-1980 SPECIFICATION FOR HEAT RESISTING STEELS

Alteration

(*Page 5, clause 5.1*) - Substitute the following for the existing clause:

'5.1 The ladle analysis of steel shall be as given in Table 1. The analysis of steel shall be carried out either by the method specified in IS:228* and its relevant parts or any other established instrumental/ chemical method. In case of dispute the procedure given in IS:228* and its relevant parts shall be referee method. However, where the method is not given in IS:228* and its relevant parts, the referee method shall be agreed to between the purchaser and the manufacturer.'

(SMDC 19)

Reprography Unit, ISI, New Delhi, India